CHAPTER

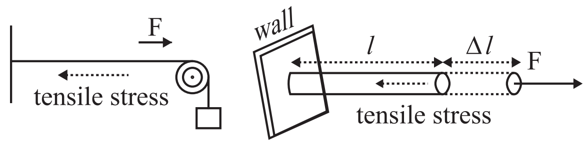
8 Mechanical Properties of Solids

Stress $= \dfrac{\text{Internal restoring force}}{\text{Area of cross} - \text{section}} = \dfrac{F_{Res}}{A}$.

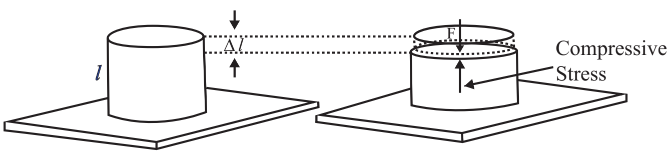
There are three types of stress:

Longitudinal Stress (2 Types)

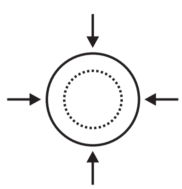
(a) Tensile Stress:



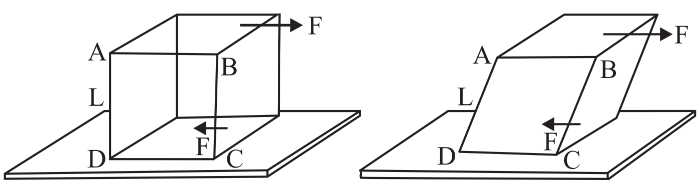
(b) Compressive Stress:



Volume Stress

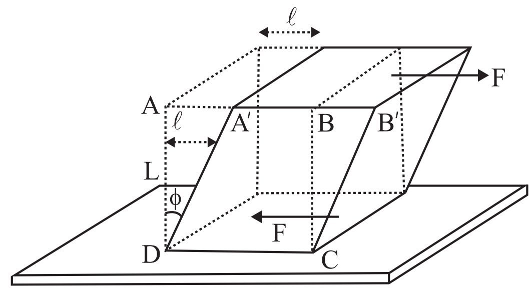


Tangential Stress or Shear Stress

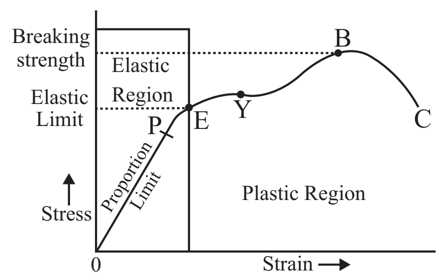


Strain $= \dfrac{\text{Change in Size of the body}}{\text{Original size of the body}}$ (3 types)

1. **Longitudinal strain** $= \dfrac{\text{Change in length of the body}}{\text{Initial length of the body}} = \dfrac{\Delta L}{L}$
2. **Volume strain** $= \dfrac{\text{Change in volume of the body}}{\text{Original volume of the body}} = \dfrac{\Delta V}{V}$
3. **Shear strain:** $\tan\phi = \dfrac{\ell}{L}$ or $\phi = \dfrac{\ell}{L} = \dfrac{\text{Displacement of upper face}}{\text{Distance between two faces}}$



Stress-Strain Curve



Hooke's Law

$\boxed{\text{Stress} \propto \text{strain}}$ **(within limit of elasticity)**

Young's Modulus of Elasticity

$$Y = \frac{\text{Longitudinal stress}}{\text{Longitudinal strain}} = \frac{FL}{A\,\Delta\ell}$$

If L is the length of wire, r is radius and ℓ is the increase in length of the wire by suspending a weight Mg at its one end, then Young's modulus of elasticity of the material of wire

$$Y = \frac{(Mg/\pi r^2)}{(\ell/L)} = \frac{MgL}{\pi r^2 \ell}$$

Increment in Length due to Own Weight

$$\Delta\ell = \frac{MgL}{2AY} = \frac{\rho g L^2}{2Y}$$

Bulk Modulus of Elasticity

$$k = \frac{\text{Volume stress}}{\text{Volume strain}} = \frac{\frac{F}{A}}{-\frac{\Delta V}{V}} = \frac{P}{-\frac{\Delta V}{V}}$$

Compressibility

$$C = \frac{1}{\text{Bulk modulus}} = \frac{1}{K}$$

Modulus of Rigidity

$$\eta = \frac{\text{shearing stress}}{\text{shearing strain}} = \frac{(F_{\text{tangential}})/A}{\phi}$$

Poisson's Ratio

$$(\sigma) = \frac{\text{lateral strain}}{\text{longitudinal strain}}$$

Work done in Stretching Wire

$$W = \frac{1}{2} \times \text{stress} \times \text{strain} \times \text{volume}$$

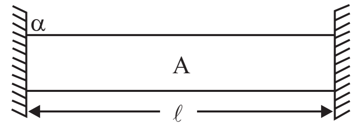
$$W = \frac{1}{2} \times \frac{F}{A} \times \frac{\Delta\ell}{\ell} \times A \times \ell = \frac{1}{2} F \times \Delta\ell$$

Rod is Rigidly Fixed at the Ends, between Walls

Thermal strain = $\alpha\Delta\theta$

Thermal stress = $Y\,\alpha\Delta\theta$

Thermal tension = $Y\,\alpha A\Delta\theta$



Effect of Temperature on Elasticity

When temperature is increased then due to weakness of inter molecular force the elastic properties in general decrease i.e, elastic constant decreases. Plastic properties increase with temperature.